B. TECH. SEM - III (CHEMICAL ENGG.) 2014 COURSE) (CBCS) :
WINTER - 2017
SUBJECT : CHEMICAL PROCESS CALCULATIONS

Day **Friday** Time : **10.00 AM TO 01.00 PM**
Date **19/01/2018** Max. Marks : 60

W-2017-2019

N.B.:

1) All questions are **COMPULSORY**.
2) Figures to the right indicate **FULL** marks.
3) Use of non-programmable **CALCULATOR** is allowed.
4) Assume suitable data if **NECESSARY**.

Q.1 a) For ideal gas, prove that PV = nRT, where P = total pressure, V = volume, T = temperature, R = universal gas constant, n = number of moles. **[04]**

b) The analysis of the gas sample is given below (on volume basis): **[06]**
CH_4 = 66%, CO_2 = 30%, NH_3 = 4%.
Find : **i)** The average molecular weight of the gas
ii) Density of gas at 202.65 kPa.g pressure and 303K.

OR

Q.1 a) State and explain Raoult's law. **[04]**

b) A chemical engineer is interested to prepare 500 ml of 1 normal, 1 molar and 1 molal solution of H_2SO_4. Assuming the density of H_2SO_4 solution to be 1.075 gm/cm^3, calculate the quantities of H_2SO_4 to be taken to prepare these solutions. **[06]**

Q.2 a) Explain the general procedure to solve problems in material balance without chemical reaction. **[04]**

b) A feed to a continuous fractionating column analyses by weight 28% benzene and 72% toluene. The analysis of distillate shows 52 weight percent benzene and 5 weight percent benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feed per hour. Also calculate the percent recovery of benzene. **[06]**

OR

Q.2 a) Explain evaporation operation used in chemical industry with their block diagram and material balance. **[04]**

b) The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid. **[06]**

Q.3 a) Explain in detail limiting reactant and excess reactant. **[04]**

b) Ethylene oxide is produced by oxidation of ethylene. 100 kmol of ethylene are fed to a reactor and the product is found to contain 80 kmol ethylene oxide and 10 kmol CO_2. Calculate: **[06]**
i) The percent conversion of ethylene
ii) The percent yield of ethylene oxide.
Reactions: **i)** $C_2H_4 + 1/2\ O_2 \rightarrow C_2H_4O$
ii) $C_2H_4 + 3\ O_2 \rightarrow 2CO_2 + 2H_2O$

OR

Q.3 Monochloroacetic acid (MCA) is manufactured in a semibatch reactor by the action of glacial acetic acid with chlorine gas at 373K in the presence of PCl_3 catalyst. MCA thus formed will further react with chlorine to form dichloroacetic acid (DCA). To prevent the formation of DCA, excess acetic acid is used. A small-scale unit which produces 5000 kg/day MCA, requires 4536 kg/day of chlorine gas. Also, 263 kg/day of DCA is separated in the crystallizer to get almost pure MCA product. Find the % conversion, % yield of MCA and selectivity. **[10]**

Q.4 Fresh juice contains 15% solids and 85% water by weight and is to be concentrated to contain 40% solids by weight. In single evaporation system, it is found that volatile constituents of juice escape with water leaving the concentrated juice with a flat taste. In order to overcome this problem, part of the fresh juice bypasses the evaporator. The operation is shown schematically in figure 1 given below. Calculate : **[10]**

i) The fraction of juice that bypasses the evaporator.

ii) The concentrated juice produced (containing 40% solids) per 100 kg of fresh juice fed to the process.

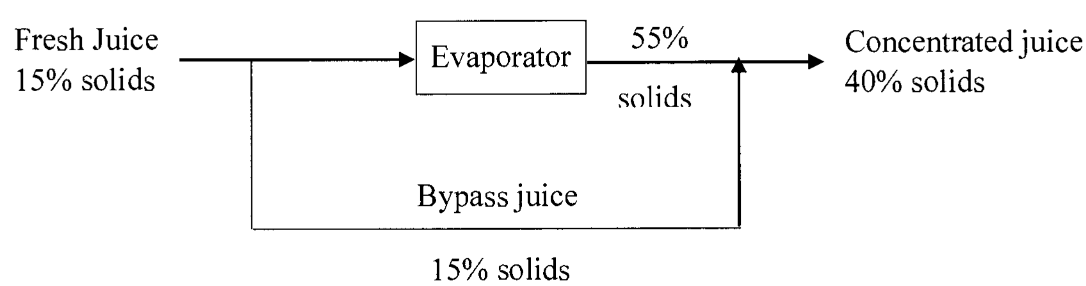

Figure 1: Block diagram for concentration of juice.

OR

Q.4 Write short notes on the following: **[10]**

a) Recycle and purge operation

b) Humidification and Dehumidification

Q.5 a) Explain Hess's law of constant heat summation. **[05]**

b) Calculate the standard heat of reaction at 298.15K of the following reaction: **[05]**

$2NaHCO_3 (s) \rightarrow Na_2CO_3 (s) + CO_2 (g) + H_2O (g)$.

Data:

Component	ΔH_f^0, kJ/mol at 298.15K
$NaHCO_3$ (s)	– 950.81
Na_2CO_3 (s)	– 1130.68
CO_2 (g)	– 393.51
H_2O (g)	– 241:82

OR

Q.5 A gas has the following composition on mole basis: **[10]**
$SO_2 = 7.09\%$, $O_2 = 10.55\%$, $SO_3 = 0.45\%$ and $N_2 = 81.91\%$.
Calculate the heat to be added to heat 1 kmol of gas from 298K to 775K using heat capacity data given below:

$$C_p^0 = a + bT + cT^2 + dT^3,\ kJ/(kmol.K)$$

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
SO_2	24.7706	62.9481	– 44.2582	11.122
O_2	26.0257	11.7551	– 2.3426	– 0.5623
SO_3	22.0376	121.624	– 91.8673	24.3691
N_2	29.5909	– 5.141	13.1829	– 4.698

Q.6 a) Explain in detail Gross and Net calorific values of fuel. **[05]**

b) The gross calorific value (GCV) of gaseous propane at 298K is 2219.71 kJ/mol. Calculate its net calorific value in kJ/mol. Take latent heat of water vapour at 298K = 2442.5 kJ/kg. **[05]**
(Reaction : $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$).

OR

Q.6 Calculate the gross and net calorific value at 298K in kJ/mol, kJ/kg and kJ/m^3 of the gas with following composition by volume: **[10]**
$CH_4 = 74.4\%$, $C_2H_6 = 8.4\%$, $C_3H_8 = 7.4\%$, i – $C_4H_{10} = 1.7\%$, n – $C_4H_{10} = 2.0\%$, i – $C_5H_{12} = 0.5\%$, n – $C_5H_{12} = 0.4\%$, $N_2 = 4.3\%$ and $CO_2 = 0.9\%$.
Take specific volume of gas at 298K and 101.325 kPa = 24.465 m^3/kmol.
Data :

Component	GCV, kJ/mol	NCV, kJ/mol
CH_4	890.65	802.62
C_2H_6	1560.69	1428.64
C_3H_8	2219.17	2043.11
i – C_4H_{10}	2868.20	2648.12
n – C_4H_{10}	2877.40	2657.32
i – C_5H_{12}	3528.83	3264.73
n – C_5H_{12}	3535.77	3271.67